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Geological Series
Bulletin No. 17

UNION OF SOUTH AFRICA

DEPARTMENT OF MINES

GLASS SANDS
OF AN
AREA NEAR PRETORIA

by

L. Meintjes, B.Sc. and H. J. Nel, M.Sc.

Publication of the Geological Survey Division

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CONTENTS

	Page
I.—INTRODUCTION	1
II.—GENERAL DESCRIPTION OF THE AREA	2
III.—THE SAND DEPOSITS	2
Bultfontein 120, Krugersdorp District	3
De Rust 18, Brits District	3
Hartbeesthoek 524, Pretoria District	4
Hartebeestpoort 308, Pretoria District	4
Pienaarspoort 176, Bronkhorstspruit District	4
Remhoogte 40, Brits District	5
Rietfontein 28, Brits District	5
Strydfontein 606, Pretoria District	6
Uitzicht 586, Pretoria District	6
Witfontein 53, Pretoria District	7
Wonderboom 311, Pretoria District	7
Zandfontein 93, Pretoria District	7
Zeekoehoek 95, Krugersdorp District	8
V.—LABORATORY EXAMINATION	9
V.—PHYSICAL AND CHEMICAL PROPERTIES OF THE SANDS	11
I.—SPECIFICATIONS	17
I.—ECONOMIC ASPECTS	19
REFERENCES	22
APPENDIX	26

LIST OF ILLUSTRATIONS

TEXT FIGURES

FIGURE PAGE

1. Tyler sieve (apertures enlarged × 50) 10

2. Histogram of grading of sample 1, Uitzicht 586 13

3. Cumulative logarithmic diagram of grading on Tyler standard screen scale 14

4. Direct diagram of grading on Tyler standard screens 14

PLATES (AT END OF TEXT)

PLATE

I. Photomicrograph of sand sample 2 (untreated), Uitzicht 586. Reflected light. Linear magnification × 8.

II. Photomicrograph of sand sample 2, − 35 + 115 fraction. Reflected light. Linear magnification × 8.

III. Photomicrograph of sand sample 2, − 35 + 115 fraction, in immersion liquid of refractive index 1·56. Transmitted light. Linear magnification × 18.

IV. Photomicrograph of glass sand from Fontainebleau (France), one of the best glass sands known, in immersion liquid of refractive index 1·56. Transmitted light. Linear magnification × 18.

V. Photomicrograph of sand sample 36, Zeekoehoek 95, − 35 + 115 fraction. Reflected light. Linear magnification × 8.

VI. Photomicrograph of sand sample 36 (acid-treated), − 35 + 115 fraction, in immersion liquid of refractive index 1·51. (Quartz = 1·55). Transmitted light. Linear magnification × 8.

GLASS SANDS OF AN AREA NEAR PRETORIA

I.—INTRODUCTION

South Africa's glass industry has developed considerably during recent years and more especially during the war. The import figures, however, show that the Union's output does not by any means satisfy local requirements. In 1938, the last year before shipping was subjected to wartime restrictions, more than £700,000* worth of glassware was imported, and even in the year 1943 the value of imports was more than £450,000.†

In the manufacture of glass approximately 60 per cent. of the batch is composed of a white, practically pure quartz sand, which must satisfy certain specifications. Sand from the Cape Flats has been used successfully for colourless glass containers for many years by the two South African factories in existence at present. These are at Talana Hill, Dundee (Union Glass Co.) and in Pretoria (Pretoria Glass Works), both a considerable distance from Cape Town. Freightage on sand from the Cape Flats to Pretoria accounts for nearly three-quarters of its delivered price and thus contributes materially to the cost of the glassware. Large quantities of colourless glass are consumed on the Reef, and if there is suitable raw material close at hand, local products may be able to meet the demands of this market.

There is a dearth of literature on South African sand deposits. In 1919 Wagner (1) described some occurrences with reference to their glass-making potentialities and referred amongst others to the sands occurring in a belt immediately north of Pretoria. This seemed the most promising inland supply, and in order to collect further information the Geological Survey has re-investigated these deposits. They lie in the Moot valley and in the strip immediately north of the Magaliesberg range between the Hartebeestpoort dam and Pretoria North. Individual deposits were not sampled or examined in any great detail, and no estimation of reserves or beneficiation costs has been made. The primary object was a reconnaissance survey, and although no comprehensive sampling was undertaken, the analyses of one or two samples from each farm indicate roughly the quality of the sands.

The chemical analyses were carried out by Dr. C. F. J. v.d. Walt and Mr. C. J. Liebenberg of the Division of Chemical Services. We are indebted to Dr. I. Donen of the Pretoria Glass Works for further analyses and various useful suggestions.

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* Annual Statement of Trade and Shipping of the Union of South Africa and the Territory of South West Africa, 1941, *pp*. 150–152.

† Annual Statement of Trade and shipping of the Union of South Africa and the Territory of South West Africa, 1943, *pp*. 121–123.

II.—GENERAL DESCRIPTION OF THE AREA

The depression separating the Daspoort and Magaliesberg ranges in the vicinity of Pretoria is locally known as the Moot valley. It owes its origin to the differential weathering of the sediments of the Pretoria series, which has resulted in the development of two prominent dip-slope ranges trending approximately east-west and composed of massive quartzites dipping at an average angle of 20° to the north. The Moot valley between these ranges is floored by intercalated shales and intrusive diabase sheets. Due north of Pretoria the valley is roughly 2 miles wide, broadening out eastwards and westwards to attain a width of some 7 miles. The basal rocks of the Bushveld igneous complex occur immediately north of the Magaliesberg quartzite.

Except for the diabase sheets, which occasionally form low, rocky ridges, rock outcrops are seldom encountered in the Moot valley. Whereas the surface soil is predominantly reddish-brown, that overlying the sand deposits is invariably more sandy and much lighter in colour. This serves as an excellent marker for the sand deposits, clearly demarcating their distribution and extent. North of the Magaliesberg the soil is also reddish, though the positions of the sand deposits are not so clearly indicated by lighter-coloured soil as in the Moot valley.

The Moot valley is endowed with a strong underground water supply. Frommurze (2) states that 30,000 gallons per 24 hours pumping is an average yield for the shales in this part of the valley.* On an average the Magaliesberg and Daspoort quartzites yield about 16,000 gallons per 24 hours pumping. Frommurze further states that the intrusive diabase sheets have also given comparatively good results. However, where the diabase is considerably weathered, drilling is not advisable.

At several of the sand deposits, notably on Zandfontein 93, Uitzicht 586, and Zeekoehoek 95, the water-table is encountered at the base of the white sand beds, from 6 to 10 feet below ground-level.

The whole area is well grassed, with a preponderance of thornbush due north of the Magaliesberg range. The annual rainfall is about 25 inches, the greatest precipitation taking place during the summer months. The area supports a fairly large rural population.

III.—THE SAND DEPOSITS

The sand deposits of the Moot valley are confined to a zone a few hundred yards wide, parallel to the Daspoort range and approximately half a mile north of it. With the exception of one farm, Pienaarspoort 176, all the deposits examined are within this zone, which has been followed for more than 50 miles. The most obvious explanation of the deposits would be to assume that disintegrated material was washed down from the dip-slopes of the Daspoort range. A study of various features of the sand deposits and quartzites and of the morphological history of the valley would, however, be necessary to settle the point. Another theory, tentatively proposed by Wagner ([1] *pp.* 534–5), is that the deposits mark the positions of outliers of Karroo sandstone.

---

* In an unpublished report Frommurze mentions that two boreholes situated in the townships of Hercules and Eloffsdal, which adjoin Pretoria, were sunk into the Pretoria shales. These have exceptional yields of 20,000 and 12,000 gallons per hour respectively.

As can be expected, the various deposits in the Moot valley and north of the Magaliesberg vary in extent and quality. Although the latter deposits are less extensive and exploited on a much smaller scale, both areas are important producers of fine-grained (< 1 mm.), light-coloured sand. It is used mainly in the building industry and, to a lesser extent, for moulding purposes and glass manufacture.

The samples used in this investigation weighed approximately 20 pounds each and were collected from freshly exposed surfaces on the walls of the pits. By lightly scraping a clean spade upwards against the surface in such a manner that the sand collected on the spade it was possible to sample any individual sand horizon fairly carefully. Where the sand deposits are not being exploited the same procedure was adopted in prospecting pits specially dug for this purpose.

The deposits will be described in alphabetical order of their farm localities, as follows :—

Farm	Sample number
Bultfontein 120	34
De Rust 18	31–32
Hartbeesthoek 524	41
Haartebeestpoort 308	12–15
Pienaarspoort 176	16–21
Remhoogte 40	33
Rietfontein 28	27–28
Strydfontein 606	39–40
Uitzicht 586	1– 5
Witfontein 53	22–23
Wonderboom 311	24–26
Zandfontein 93	7–11
Zeekoehoek 95	35–37

Bultfontein 120

A very extensive and unexploited deposit of sand adjoins the siding Die Moot on the above-mentioned farm.

The following profile was obtained :—

	Ft.	In.
Overburden of grayish, sandy soil	2	—
White sand (sample 34)	6	—

De Rust 18

Profile :—

	Ft.	In.
Pale gray, sandy soil	2	6
White sand (samples 31 and 32)	3	6

The above profile is an average result obtained in a pit, flanked on hree sides by bluegum trees, adjoining the Nefdt siding—Scheerpoort oad. A large amount of sand is apparently available within this bluegum enclosure.

Hartbeesthoek 524

Extensive deposits of fine-grained, light-coloured sand occur on the central portion of Hartbeesthoek 524, north of the Magaliesberg. The pits are situated to the south of the Pretoria North–De Wildt road and are easily accessible.

The following profile is representative of a pit in the south-east corner of a patch of ground some 400 yards square, fringed on all sides by large bluegum trees :—

	Ft.	In.
Overburden of brown, sandy soil..............	2	—
Light-coloured sand (sample 41)................	4	—

South of this pit are also extensive reserves of reddish, ferruginous sand.

Hartebeestpoort 308

Sand-pits that are still being worked on a small scale are situated approximately 600 yards west of the Silverton post office and police station and adjoin the Pretoria—Premier Mine road on the north.

The following profiles were obtained in the pits :—

	Ft.	In.
1. Gray, sandy soil.........................	2	6
Gray sand with ferruginous streaks and rootlets (sample 12).....................	3	6
Clayey sand.		

	Ft.	In.
2. Brown sand with lighter-coloured streaks, thickness irregular (sample 13)..........	2 to 4	—
Gray, clayey sand (sample 14).............	1	6
Gray sand, more clayey than foregoing (sample 15).........................	1	—

The light-coloured sand from this locality is much more clayey than the corresponding sand from other deposits in the Moot valley. A large amount of sand is available at these pits.

Pienaarspoort 176

The deposit on this farm is the only one investigated (apart from those north of the Magaliesberg) that is more than a mile north of the Daspoort.

Pienaarspoort 176 is some 16 miles due east of Pretoria. The deposit is approximately a mile east of the siding Pienaarspoort and lies immediately south of the Pretoria—Middelburg railway line.

When Wagner described this sand in 1919, it was being used by the Hatherley glass factory, now defunct. According to him it was the only South African sand then successfully employed on a large scale for making glass.

At present the faces of these pits, which have not been worked for a considerable time, have collapsed and are overgrown with grass. This has made it difficult to obtain representative samples without embarking on a detailed prospecting scheme. For the same reason it was not possible to assess the reserves available. Wagner ([1] *p.* 447), however, stated that the deposit appeared to be of considerable extent and that boreholes had proved the sand horizon to be 90 feet thick.

Sample 21, taken from an old pit near the railway line, is probably the glass sand used by the old Hatherley glass works.

The following profile is exposed in this pit :—

	Ft.	In.
Brownish, sandy loam......................	2	—
Yellowish sand (sample 20)...................	2	—
White sand (sample 21), exposed thickness.....	3	—

Sample 16 was taken near the eastern extremity of the old workings. A pit dug there proved the sand to be at least 4 feet thick. When dry the sand is nearly white.

Samples 17, 18, and 19 were obtained from different pits dug at random in the old excavations. In every case the sand horizon sampled was overlain by some 2 feet of overburden, the yellowish sand beds themselves varying in thickness from 2 to 4 feet. However, the main interest centres round the white sand as represented by sample 21. The other samples were collected mainly to show the variation in the material available at this deposit. Further information regarding heavy mineral assemblage and grading of the Pienaarspoort sands may be obtained from Wagner's report.

Probably a sufficiently strong underground water supply could be tapped in the immediate vicinity of the deposit to enable washing and screening of the sand prior to despatch to the factory.

At this deposit, perhaps even more so than at the others described, very careful prospecting by means of pits, trenches, and possibly boreholes will have to be undertaken in order to arrive at a fair approximation of the reserves of white sand available.

Remhoogte 40

The deposit on this farm is only of limited extent and not considered worthy of further investigation. As will be seen from the table on page 7 this sand (sample 33) does not compare favourably with the material from the large deposits of Zeekoehoek 95 or Uitzicht 586.

Rietfontein 28

An unexploited deposit of possible interest occurs on the extreme eastern portion of this farm, immediately north of Longmeadow halt. The deposit is about 150 yards wide and extends parallel to the railway line for a distance of approximately 1,000 yards up to the Uitzicht boundary.

The following profile was obtained in a prospecting pit 80 yards north of Longmeadow :—

	Ft.	In.	
Gray, sandy soil (sample 27)..................	3	6	
White sand (sample 28)......................	3	—	(at least)

The comparatively high cost of stripping the overburden may possibly be offset by disposing of at least part of it for building purposes.

Strydfontein 606

Samples 39 and 40 were obtained from small pits on the southern portion of this farm, a few hundred yards south of the Horn's Neck—Hartebeestpoort dam road. An overburden of 1 foot 6 inches overlies the white sand horizon, which is 3 feet thick here. In places the whit sand, of which a fairly large amount is available, is rather clayey and wil probably be suitable for building purposes.

Uitzicht 586

Situated some 15 miles west of Pretoria, this is the most important sand-producing farm in the Moot valley. The extensive deposits are being actively exploited.

The pits on the western portion of Uitzicht 586 are all situated i the immediate vicinity of Iswin siding, near the eastern boundary o Rietfontein 28.

From Mr. J. Levin's pit the sand is transported to Iswin siding which is 400 yards to the south-west, by means of cocopans on a narrow-gauge railway line.

Profile :—

	Ft.	In.
Gray, sandy top soil	3	—
White sand (sample 1)	3	—
Hard, clayey sand.		

The following profiles were obtained in the Pretoria Sand Company' pits :—

1. Immediately south of Iswin siding :—

	Ft.	In.
Gray-brown top soil merging downwards into white sand	2	—
Homogeneous white sand (sample 3) (Farther northwards in the pit this thins down to 3 feet).	5	—
Hard, clayey sand.		

2. Half a mile W.N.W. of Iswin siding :—

	Ft.	In.
Brownish top soil	2	—
White sand (sample 2)	7	—

Mr. J. Levin supplies the Union Glass Works, Talana, Natal, wit the fine, white sand for the manufacture of glassware. The Pretori Sand Company supplies similar sand for moulding purposes and for mixing with cement. The overburden, with the possible exception of the uppermost foot of soil, is usable for building purposes.

The Pretoria Glass Works have acquired the right to work the san deposits on the central portion of Uitzicht 586, approximately half mile east of Iswin siding. A washing and screening plant has bee erected at the pit in order to beneficiate the sand before despatch to the factory for use in glass manufacture. The white sand bed of 3 feet 6 inches is covered by 2 to 3 feet of overburden, which could possibly be disposed of for building purposes.

The pits on the eastern portion of the farm are about 1½ miles south of the Swartspruit hotel on the Pretoria—Hartebeestpoort dam road. The sand from these pits is mostly used in the building industry and for this purpose is trucked to the Reef from Iswin siding or sold at the pits. The large reserves available assure the deposit a long productive life.

The following profiles were obtained in the pits :—

1. South wall of pit :—

	Ft.	In.
Brown-gray, sandy soil	2	—
White sand with rootlets, no ferruginous stains present, fresh surface soft and crumbly but hardens on exposure (sample 4)	3	—
Hard, clayey sand.		

2. West wall of pit :—

	Ft.	In.
Overburden of brownish sand	3	—
White sand with superficial iron oxide stains (sample 5)	3	—
Hard, clayey sand.		

Witfontein 53

Sand from the fairly large deposits on this farm is used mainly in the building industry. The following profile was obtained in a pit situated immediately south of the Pretoria North–De Wildt road, on Mrs. Yates' portion of Witfontein :—

	Ft.	In.
Sandy soil, thickness variable	2 to 4	—
White sand with numerous superficial iron oxide stains and rootlets from nearby bluegum trees (samples 22 and 23 taken 40 yards apart)	4	—

Wonderboom 311

The extensive deposits on the western portion of this farm are situated south of the Pretoria North—De Wildt road. Sand derived from here is also used mainly for building purposes.

Samples 25 and 26 are considered to be representative of the best sands available in the area with a view to glass manufacture. Sample 24 was collected on the north side of the above-mentioned road and is overlain by 2 feet of sandy soil.

Not only is the sample material unpromising as a glass sand, but it is also highly improbable that a consistent grade could be delivered from these deposits, due to many years of haphazard exploiting.

Zandfontein 93

The sand-pits investigated on this farm are situated south of the Pretoria—Hartebeestpoort dam road, within a mile of Gomsand siding. They are being exploited by the Sand Supply Company, Pretoria.

This deposit was described in some detail by Wagner ([1] *p.* 53
He considered the white sand found here suitable for white bottles a
better-grade glassware, and after effective washing and screening in
likelihood suitable for plate glass

Since the publication of Wagner's report in 1919 most of the whi
sand mentioned has been removed for building and, to a lesser exten
for moulding purposes. Samples of this sand (7 and 8) were taken f
comparative purposes. However, it seems unlikely that the reserv
available at present are sufficiently large to warrant economic interes
Owing to their regular distribution of the deposit it is also unlikely tha
consistent grade for the manufacture of colourless glassware could
delivered in large quantities.

The following profiles from the Sand Supply Company's pits may
taken as fairly representative :—

1. Eastern pit :—

	Ft.	In.	
Reddish sand with rootlets and superficial iron oxide stains	4	—	
Grayish, fine-grained sand intermediate in colour between reddish and light gray	2	—	(arbitrary thickness)
Light gray sand (samples 7 and 8)	3	—	
Blackish sand that washes clean very easily, thickness variable (sample 9)	3	—	(approx.)
Top of water-table.			
Hard, clayey sand.			

2. Western pit (southern face) :—

	Ft.	In.
Brownish, sandy soil	1	—
Light brown sand with superficial iron oxide stains and rootlets (sample 10)	5	—
Hard, clayey sand.		

3. Western pit (northern face) :—

	Ft.	In.
Brown, sandy soil	1	—
Fine-grained, light brown sand with superficial iron oxide stains and rootlets (sample 11)	4	—
Hard, clayey sand.		

Large quantities of the light brown sand are available in the weste
pits area. There should be a sufficiently large underground water supp
for washing the sand at the deposit if required.

Sand from this farm is mostly used in the building industry.
red-brown, loamy sand found at the base of the Daspoort dip-slope on t
eastern portion of Zandfontein 93 is used extensively for mouldi
purposes.

Zeekoehoek 95

This farm is approximately 23 miles south-west of the Hartebees
poort dam and immediately north of the Witwatersberg, which is t
westerly continuation of the Daspoort range. The sandpits are in t
south-west corner of the farm, a mile south of Elberta siding.

The following profiles were obtained :—

1. Western pit (southern face) :—

	Ft.	In.
Overburden of brownish, sandy soil...........	3	—
Yellow sand with superficial iron oxide stains (sample 35)................................	3	6
White sand (sample 36).......................	3	6
Top of water-table.		

2. Western pit (western face) :—

	Ft.	In.
Overburden of brownish, sandy soil grading downwards into yellow sand................	2	6
Yellow sand with superficial iron oxide stains (sample 37)................................	3	—
White sand (sample 36).......................	3	6
Top of water-table.		

The deposit is being worked. The fine-grained, white sand given in the profiles is supplied as a steel moulding sand, and the overlying material s disposed of for building purposes. Approximately 1,500 cubic yards of sand are obtained monthly from the pits on this farm. Surface indications suggest that a large amount of sand is available at this locality. Possibly the deposit also extends on to the adjoining farm New Thorndale 02. This should be worthy of further investigation.

IV.—LABORATORY EXAMINATION

In the routine control of industrial sands and in the investigation of eposits laboratory tests serve a useful purpose ; they can also supply certain amount of information concerning beneficiation possibilities.

The examination of sands for glass manufacture may be divided into the mechanical, chemical, and mineralogical aspects. By coning and uartering the samples collected in the field small representative portions re obtained, suitable for laboratory handling (in this case approximately 00 grams). These portions are then redivided for the various analyses.

The mechanical analysis of unconsolidated or crushed material has een defined as the determination of " the relative proportions, by weight, of grains between certain limits of size. " In order to accomplish his the sample is shaken through a nest of sieves with apertures of nown measurements. For this purpose various standard sieves are rocurable, the most commonly used being the Tyler, the B.S.I.(British tandards Institute), and the A.S.T.M. (American Society for Testing aterials) series. In this investigation Tyler sieves (see fig. 1) were mployed, the particulars of which are given in the table below. Inividual sieves are referred to by their mesh numbers (number of wires er inch of mat surface). Material retained on the 28-mesh sieve is ecorded as " + 28 "; material passing through the 28-mesh and etained on the 35-mesh is recorded as " − 28 + 35 ", and so on for ucceeding sieves. Samples of approximately 100 to 150 grams were ieved on a Ro-Tap mechanical sieve shaker for 20 minutes. For urposes of comparison the nearest B.S.I. and A.S.T.M. sieves are given.

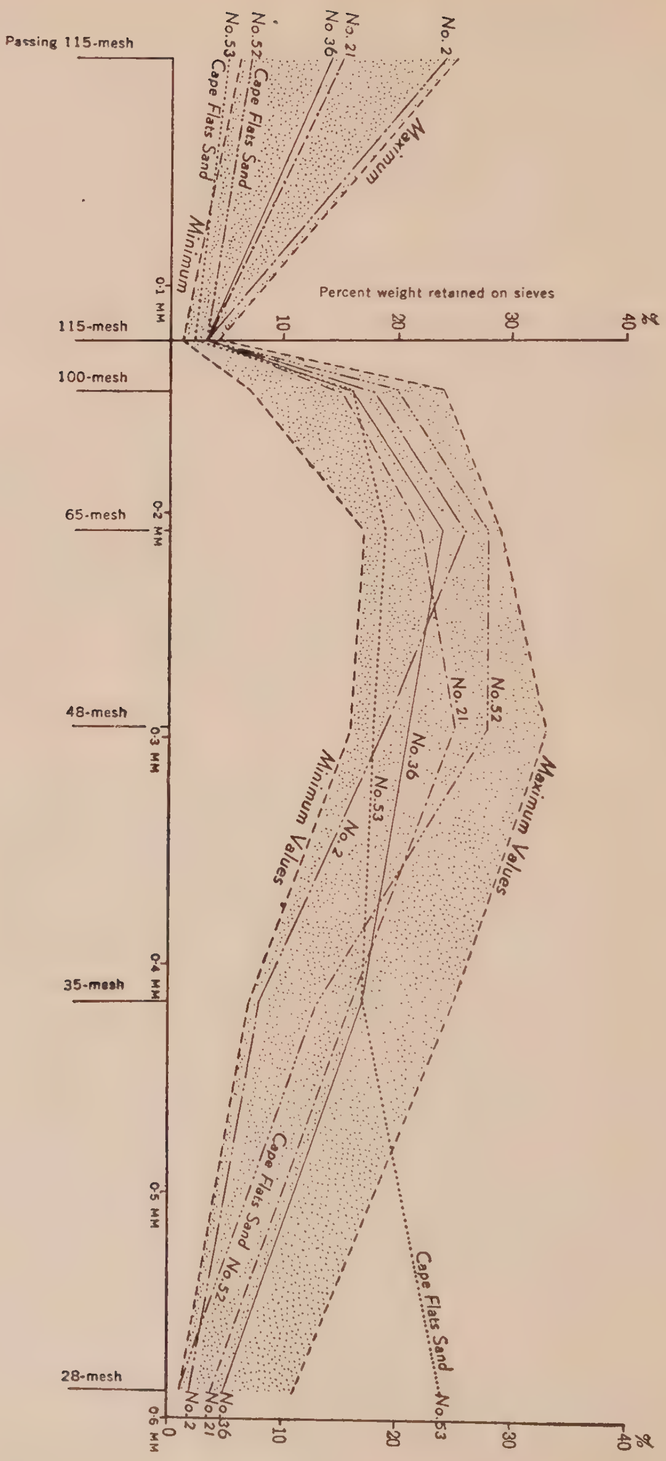


FIG. 1.—Tyler sieve (apertures enlarged × 50).

Tyler		Nearest B.S.I. sieve		Nearest A.S.T.M. sieve	
Mesh	Aperture (millimeters)	Mesh	Aperture (millimeters)	Number	Aperture (millimeters)
28	0·589	25	0·599	30	0·590
35	0·417	36	0·422	40	0·420
48	0·295	52	0·295	50	0·297
65	0·208	72	0·211	70	0·210
100	0·147	100	0·152	100	0·149
115	0·124	120	0·124	120	0·125

In preparation for chemical analysis each representative sample was further divided to give portions for one or both of the following treatments :—

(i) Sieving through 35- and 115-mesh Tyler sieves to give the grade $-35+115$, as this is the important fraction for glass-making.

(ii) Heating the $-35+115$ grade with concentrated hydrochloric acid for 20 minutes. This removes most if not all of the iron oxide adhering to the grain-surfaces and discrete grains of iron oxide (minute quantities of magnetite, etc.). A few unsieved samples were similarly treated.

The iron content (expressed as Fe_2O_3) was determined by the method given by Chirnside and Pritchard ([3]). In this method tartaric and thioglycollic acids are used.

The sands were examined under both a low power binocular and a petrographic microscope, and a few heavy residue percentages were determined after separation in bromoform without preliminary crushing. Contaminating films on the grains and internal staining were best observed with reflected light under the binocular, using mounts in Canada balsam or cedar wood oil, against a white background. A black background shows up flaws. For observation of shapes and surfaces unmounted grains proved most suitable.

V.—PHYSICAL AND CHEMICAL PROPERTIES OF THE SANDS

The results of the laboratory determinations are given in the table on page 27. The number of chemical analyses had to be limited to selected samples. In the column headed " Treatment of sample " are details of the various treatments to which portions of the samples were subjected in order to estimate their suitability for simple beneficiation ; portions referred to as " Untreated " are representative of the field samples. Analyses were also made of two samples obtained from a producer of

Cape Flats sand. It was stated that one of these had been taken from the walls of the pit, and that the other had been dried and screened.

The photomicrographs (plates I, II, III, V, VI) illustrate some features of the Pretoria sands. For comparison a sample of the world-famous glass sand from Fontainebleau (France) was photographed under the same conditions (pl. IV.).

The sands consist almost entirely of quartz grains coated in varying degrees with small amounts of ferruginous, clayey material. Most of the grains are flawed and many of them internally stained. The shape of the grains is, in general, sub-angular, but the larger ones are often rounded. The grain-surfaces are mostly rough.

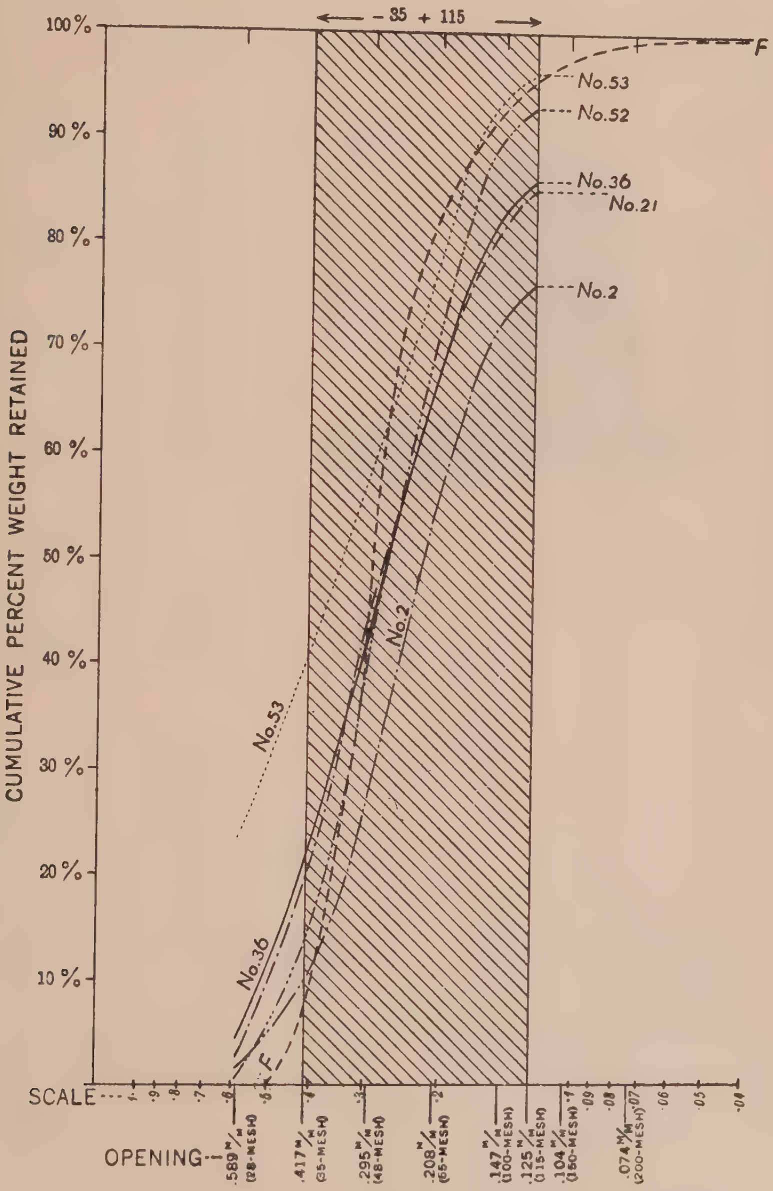
The Silverton sands are noticeably contaminated with clay. Sample 15, for example, showed distinct coatings on the grains even after 5 minutes sieving on a mechanical shaker. Sample 26 from Wonderboom is also clayey. Isolated sands are discoloured by small amounts of black, organic material. The heavy mineral percentages of a few samples are given below :—

Sample number	Farm	Percentage of minerals of specific gravity greater than 2·9
2	Uitzicht 586	0·1
21	Pienaarspoort 176	0·1
23	Witfontein 53	0·2
28	Rietfontein 28	0·1
34	Bultfontein 120	0·1
36	Zeekoehoek 95	0·2

The heavy residues include such minerals as magnetite, ilmenite, tourmaline, zircon, rutile, chromite, andalusite, and leucoxene, some of which are rich in iron. Judging from the grain size under the microscope the greater number of grains would probably fall into the −115 fraction.

Iron is, therefore, present in small amounts in the form of (*a*) dispersed ferruginous coatings, (*b*) internal stains, and (*c*) discrete iron-bearing minerals.

To illustrate the quantitative distribution of the grades in a Pretoria and the mechanical analysis of sample 1 is presented in the form of a istogram: —

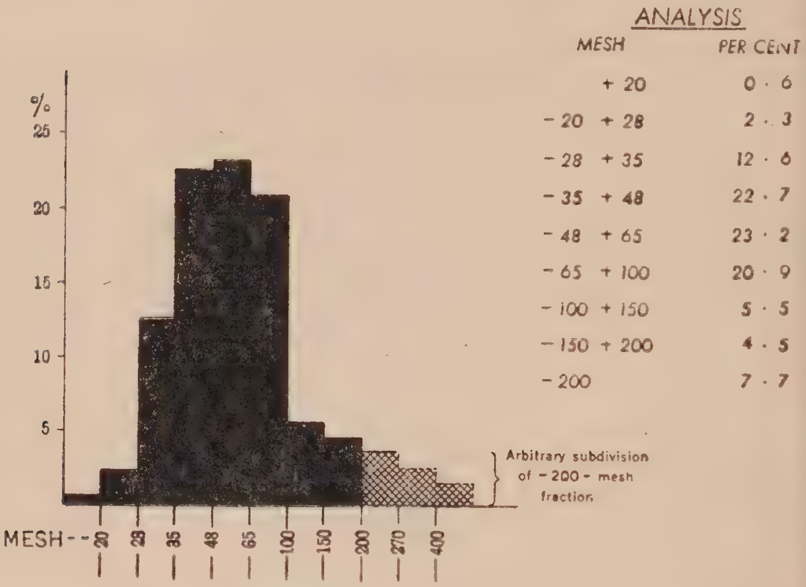


F = Fontainebleau glass sand

(Analysis No. 1 on page 87 of "A memoir on British resources of sand suitable for glass-making" by P.G.H. Boswell, 1916.)

FIG. 2.—Histogram of grading of sample 1, Uitzicht 586.

The following is a logarithmic diagram of a few Pretoria sands an the two Cape samples previously mentioned :—



ANALYSIS

MESH	PER CENT
+ 20	0 · 6
– 20 + 28	2 · 3
– 28 + 35	12 · 6
– 35 + 48	22 · 7
– 48 + 65	23 · 2
– 65 + 100	20 · 9
– 100 + 150	5 · 5
– 150 + 200	4 · 5
– 200	7 · 7

FIG. 3.—Cumulative logarithmic diagram of grading on Tyler standard screen scale

Below is a graph showing the variation in grading of the Pretor samples :—

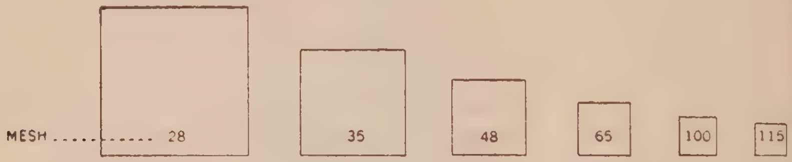


FIG. 4.—Direct diagram of grading on Tyler standard screens.

The mechanical composition of the sand is reasonably consisten throughout the length of the area examined, which covers a distance o more than 50 miles. The fraction of most importance to the gla industry, i.e. the – 35 + 115 portion, varies from 57 to 79 per cen in these sands, disregarding two poor quality sands, samples 15 and 3

The chemical constituents silica and iron are the primary conside ations in examining a sand for glass-making. The silica content of th white sands of the Moot valley is high :—

Sample number	Farm	SiO_2 content (per cent.)
2 (untreated)	Uitzicht 586	98·9
21 (untreated)	Pienaarspoort 176	
3 (untreated)	Uitzicht 586	
36 (untreated)	Zeekoehoek 95	98·3
32 (untreated)	De Rust 18	

The lowest Fe_2O_3 content of the untreated samples analysed is that of sample 8, but only very small amounts of material of this quality are available. Other untreated samples gave the following results :—

Sample number	Farm	Fe_2O_3 content (per cent.)
2	Uitzicht 586	0·098 (average)
5	Uitzicht 586	0·099
21	Pienaarspoort 176	0·109 (average)
28	Rietfontein 28	0·113 (average)
3	Uitzicht 586	0·120

The iron oxide content of the untreated samples is in each case greater than the British specification maximum of 0·04 per cent. (see p. 7) for colourless glass, but results of analyses of various fractions of a sample from Uitzicht 586 show that its iron oxide content may be decreased by removal of the fine material :—

Fractions on B.S.I. sieves	+ 36 (per cent).	− 36 + 100 (per cent.)	− 100 + 120 (per cent.)	− 100 + 150 (per cent.)	− 150 (per cent.)
Mechanical analysis....	22	66	2	2	9
Fe_2O_3 content of fraction	0·030	0·045	0·117	0·137	0·525
Fe_2O_3 as percentage of total sample.........	0·007	0·030	0·002	0·003	0·047

Analyst : I. Donen.

The above results show that there is a progressive increase in the Fe_2O_3 content with diminution of grain size. This tallies with the previous observation that fine, clayey material, much richer in iron than the quartz grains, is dispersed in the sand ; the heavy minerals add their quota of iron to the fine. In the above sample more than half of the total Fe_2O_3 content is contributed by the −120 fraction, i.e. by material whose fineness already renders its removal advisable if the sand is to be used for glass-making.

Due to their low iron content the " glass fractions ", viz. − 35 + 115 Tyler, of the following sands are considered the more promising :—

Sample number	Farm	Fe_2O_3 (per cent.)	Comparison with specifications of U.S. Bureau of Standards
2	Uitzicht 586	0·05	Sheet, plate, and inferior glasses.
11	Zandfontein 93		
14	Hartebeestpoort 308		
21	Pienaarspoort 176	0·06	
25	Wonderboom 311		
28	Rietfontein 28		
36	Zeekoehoek 95	0·07	Window glass and green and amber glass.
32	De Rust 18	0·09	

Although samples 3 and 5 from Uitzicht 586 were not analysed, they appear, from inspection, to fall within this group of sands.

Further reduction in Fe_2O_3 content* can be achieved by acid treatment of the − 35 + 115 fraction. Of the results obtained from concentrated acid treatment the following are the lowest :—

Sample number	Farm	Fe_2O_3 content (per cent.)
2	Uitzicht 586	0·028
28	Rietfontein 28	0·041
36	Zeekoehoek 95	0·046
21	Pienaarspoort 176	0·057
32	De Rust 18	0·073

To these must be added sample 23, which was examined by Dr. I. Donen and returned a Fe_2O_3 content of 0·052 per cent. on acid treatment of the − 36 + 100 B.S.I. fraction, showing a reduction of its Fe_2O_3 content by two-thirds. The partial removal of iron oxide by acid treatment of some of the glass fractions varies from approximately 10 per cent. (cf. sample 21) to 50 per cent. (cf. sample 2), indicating that the proportion of iron oxide in the form of grain-coatings is variable.

The alumina content of two samples was determined and proved low enough for glass-making. In any case, where Al_2O_3 is present in the form of clay, much of it is removed by the washing processes to which most glass sands are subjected before use. On screening alone the Al_2O_3 content of sample 28 (− 35 + 115 Tyler) was reduced from 0·875 to 0·137 per cent. Screening also removed titania, which was present in the untreated sample in an amount slightly greater than the recommendation of the Society of Glass Technology for general colourless glassware.

The heavy residues of these sands contain minerals that are iron-bearing and minerals that melt with such difficulty that they are liable to remain undigested in the melt, e.g. zircon, rutile, etc. Their proportion in the sands examined is, however, so small that the impurities thus contributed to the glass mixture are insignificant.

When compared with the specifications some of the deposits in the Moot valley proved to be border-line sands. The factories prefer, it is true, to use one sand for all types of general colourless glassware, but some of the Pretoria sands could, if it is industrially feasible, be used after beneficiation for sheet, plate, and inferior types of glass.

For comparative purposes a sample of Cape Flats sand was analysed, and it was found that even the best Moot valley sample contained more iron oxide :—

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* *See* chapter VII of this report for beneficiation results obtained by Mr. W. R. Liebenberg of the Government Metallurgical Laboratory, Johannesburg.

Iron oxide content	Cape sample 53 (per cent.)	Pretoria sample 2 (per cent.)
Fe_2O_3 of − 35 + 115 portion....................	0·019	0·053
Fe_2O_3 of − 35 + 115 portion (acid-treated).......	0·015	0·028

These figures suggest the possibility of mixing the two sands for etter quality glassware.

VI.—SPECIFICATIONS

A good glass sand is almost pure colourless silica, even-grained, and bout as fine as white table-sugar. It should not contain more than a ninimum of colouring oxides (most commonly those of iron). Coarse nd very fine grades are deleterious and therefore practically ruled out n the specifications. Large grains give rise to " stones " in the finished roduct, whereas the fine grains are liable to cause " blowing " out and rothing and usually contain much of the impurities. The angularity f the grains has been said to have a negligible effect on the melting ate of the glass batch.

Various specifications have been drawn up. That of the Society of lass Technology (Britain) is as follows* :—

(a) Grading

Specification requirements		Nearest Tyler sieve
Remaining on B.S.I. sieve No. 16......	Nil	16-mesh
Remaining on B.S.I. sieve No. 25......	Not more than 1 per cent.	28-mesh
Remaining on B.S.I. sieve No. 36......	Not more than 5 per cent.	35-mesh
Passing B.S.I. sieve No. 100...........	Not more than 10 per cent.................	100-mesh
Passing B.S.I. sieve No. 120...........	Not more than 5 per cent.	115-mesh

(b) Chemical composition

Class of glassware	Minimum silica (SiO_2) content (per cent.)	Maximum iron oxide (Fe_2O_3) content (per cent.)	Maximum titania (TiO_2) content (per cent.)
High-grade domestic and decorative glassware..	99·0	0·02	0·05
General colourless glassware including containers..............	98·5	0·04**	0·10

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* Journal of the Society of Glass Technology, XXVII, 123, October 1943.

** " During the war period . . . manufacturers of colourless glass bottles have been willing if necessary to accept sand of 0·05 per cent. iron oxide content, and even in one case up to 0·06 per cent. would not have been refused."(4).

Other colouring oxides should not be present in proportions such as to produce in the test glasses made from trial melts a colour noticeably different from that in a similar trial melt made from a sand known to be satisfactory. Should the colour be noticeably different from that expected from the iron oxide content alone, the presence of colouring oxides other than that of iron is to be suspected.

Weigel (5) gives the following specifications, recommended by the American Ceramic Society and the United States Bureau of Standards :—

(*a*) *Grading*

Through a No. 20 screen (A.S.T.M.).............	100 per cent.
Through a No. 20 and remaining on a No. 40 screen	Not more than 60 or less than 40 per cent.
Through a No. 40 and remaining on a No. 60 screen......................................	Not more than 40 or less than 30 per cent.
Through a No. 60 and remaining on a No. 100 screen......................................	Not more than 20 or less than 10 per cent.
Through a No. 100 screen......................	Not more than 5 per cent.

(*b*) *Chemical composition*

Quality	Minimum SiO_2 (per cent.)	Maximum Al_2O_3 (per cent.)	Maximum Fe_2O_3 (per cent.)	Maximum Cao+Mgo (per cent.)
First quality, optical glass...........	99·8	0·1	0·020	0·1
Second quality, flint glass containers, tableware........................	98·5	0·5	0·035	0·2
Third quality, flint glass............	95·0	4·0	0·035	0·5
Fourth quality, sheet glass, rolled and polished plate..........................	98·5	0·5	0·060	0·5
Fifth quality, sheet glass, rolled and polished plate..........................	95·0	4·0	0·060	0·5
Sixth quality, green glass containers and window glass.................	98·0	0·5	0·300	0·5
Seventh quality, green glass.........	95·0	4·0	0·300	0·5
Eighth quality, amber glass containers	98·0	0·5	1·000	0·5
Ninth quality, amber glass..........	95·0	4·0	1·000	0·5

The Industrial Development Corporation of South Africa has recently indicated that the following type of sand could be used for sheet glass provided the other constituents of the glass batch are obtainable in a sufficiently pure state :—

(*a*) SiO_2 content—not less than 95 per cent. Al_2O_3 content—not to exceed 2 per cent. Iron content (total)—not to exceed 0· per cent. Other colouring oxides (chromium, cobalt, nickel etc.) must not be present.

(*b*) The grading must be such that 100 per cent. passes a 14-mesh B.S.I. sieve and not less than 90 per cent. is retained on a 100-mesh B.S.I. sieve.

At present, however, the demand is for a higher quality sand.

Boswell (6 *p.* 34) states that for plate glass sands containing 0·1 per cent. Fe_2O_3 may be used ; Fettke (7 *p.* 53) quotes a limit of 0·2 per cent.; and Weigel (5 *p.* 135) mentions a permissible maximum of 0·15 per cent.

It has been stated that sand for mirrors should contain not more than 0·1 per cent. Fe_2O_3.

For window glass the iron oxide and alumina content of suitable sands have been variously stated as follows :—

	Maximum percentage desirable		Maximum percetange permissible		Sand used for window glass (per cent.)	
(*a*)* . .	Fe_2O_3	Al_2O_3	Fe_2O_3	Al_2O_3	Fe_2O_3	Al_2O_3
(*b*)* . .	0·15				0·30–0·35	
(*c*)* . . .					0·36	1·06
(*d*)* . .	0·10	0·50	0·25	1·00		
(*e*)† . . .			0·50			

* (5 *pp.* 134–5).
† (7 *p.* 53).

Alumina decreases the fusibility of the batch, but a low percentage is not considered harmful for ordinary varieties of glass ; it has, in fact, a favourable influence on certain physical properties of the glass. In special glasses, where a high Al_2O_3 content is required, it is added in some other form. To quote Wagner (1 *p.* 438), " the presence of small amounts of titanium, aluminium, calcium, and alkalies is of little importance except in so far as the best grades of glass and optical glass are concerned. "

VII.—ECONOMIC ASPECTS

Data obtained from the examination of sand samples from the area under dicussion suggest a variety of uses in our glass industry : bottles, shelving, table-tops, glass bricks, window panes, mirrors, etc., some of which have already been made in this country. The sands contain a certain amount of fine material and impurities deleterious to glass-making, but both the grading and purity can be improved by simple beneficiation such as screening. The better sands could be rendered suitable for ordinary colourless glassware, the quality of which would largely depend upon the extent of beneficiation. One cannot expect hese laboratory results to be duplicated under commercial conditions, but investigation into the various known industrial methods would eveal their effectiveness and economic feasibility in this area, e.g. waterwashing with scrubbing action ; tabling ; the Adams (8) reduction process ; treatment with acid, sodium carbonate, nitre cake, or common salt ; etc. With the aid of laboratory control a check can be kept on the sand delivered and also on all the other ingredients of the glass batch. As the purity of natural products is more difficult to ensure than that of manufactured products, any permissible latitude should, wheneve possible, be reserved for the sand.

The laboratory tests and rough field observations attract attentio to the following farms : Uitzicht 586 (sample 2), Zeekoehoek 95 (sampl 36), Pienaarspoort 176 (sample 21), and Rietfontein 28 (sample 28).

Some investigations of the Government Metallurgical Laboratory Johannesburg, are of interest here. In his " Interim Report on Sout African Sands and Crushed Rocks for Glass Manufacture", June 1944 W. R. Liebenberg reports that water-washing in a bottle agitator for 3 minutes gave products with the following Fe_2O_3 content :—

Six white sands from Pienaarspoort 176, Uitzicht 586, Rietfontein 28, and Zeekoehoek 95	0·05–0·07 per cent.
Three brownish sands from Pienaarspoort 176 and Zeekoehoek 95	0·09–0·11 per cent.

He concluded that this water-washing was as effective as treatment wit sodium acid oxalate (plus ferrous sulphate) or diluted sulphuric aci By means of the two latter treatments the iron content of three samples Pretoria sands containing 0·22, 0·13, and 0·17 per cent. Fe_2O_3 respectively was reduced to 0·07 per cent., with the exception of on result of 0·06 per cent., which was given by a sample from Uitzicht 58 treated with sulphuric acid. Wilfley tabling was found to be a slightl more effective method with a clean sand, due to removal of ferruginou heavy minerals (sample from Uitzicht 586). It is not, however, s effective in improving a sand that requires scrubbing in order to cleans the grains of adhering contamination.

Geographically the Pretoria sands are close to South Africa's larges market, viz. the Reef. This is an important factor, as the local price glassware largely depends on overland transportation costs.

Fuel does not present any great difficulties, as the coalfields are no far distant.

Transport facilities serve the area well. There are a number of goo roads near the deposits, connecting them with Pretoria, Johannesburg and Krugersdorp. The Pretoria—Krugersdorp railway line runs parall to the sand belt and is never much more than a mile distant. There ar many sidings all along this line, and its eastern continuation passe through Pienaarspoort 176. The freightage on sand between Magaliesburg station and Pretoria is at the time of writing ½d. per mile per to with a minimum charge of 1s. 3d. per ton.

Electrical power is procurable on several farms, due to the proximit of the Pretoria—Brits overhead power-line.

Water supplies in this area are satisfactory, as there are more o less perennial streams, and there is little difficulty in tapping underground sources. This ready supply of water may enable washing (an screening) of the sands to be carried out economically at the pits ; thi procedure would remove unwanted grades and impurities and reduc transport and handling costs.

Soda ash occurs in the Pretoria salt-pan, and salt cake is manufactured on the Reef.

Although the Pretoria sands fall below the standard of the best overseas deposits and those of the Cape Flats, they will continue to attract attention. The deposits are large, and if scientific methods are applied it should be possible to produce raw material of satisfactory quality. The economic success of the production of colourless glass from these sands will depend mainly on the balance struck between the cost of improving them and the advantages of their geographical position. It remains for private enterprise to examine the industrial factors and to investigate whether the available quantities (as affected by beneficiation possibilities) will be sufficient to warrant the investment of capital. Meanwhile the white sands are in danger of being greatly depleted by their use in the building industry where a lower quality would be equally suitable, and it is desirable, in the interests of the country, that the best sands be retained for more specialised purposes. We have here a reserve of sands that only require proper treatment to raise them to the status of good glass sands.

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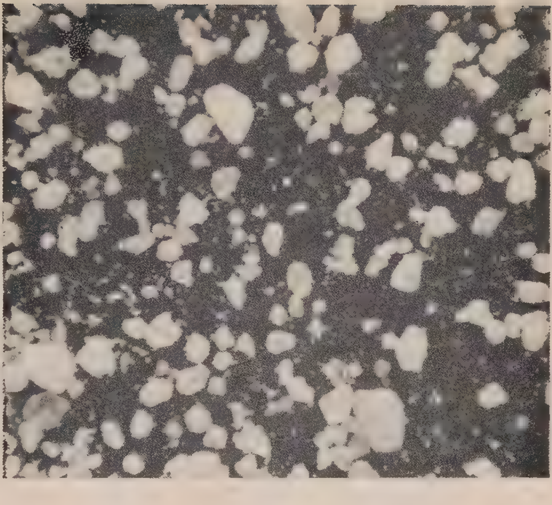

Plate I.—Photomicrograph of sand sample 2 (untreated), Uitzicht 586. Reflected light. Linear magnification × 8.

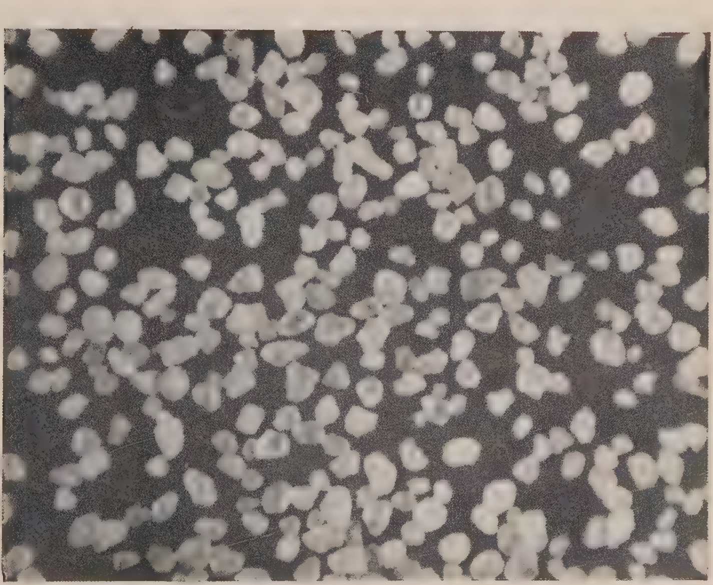

Plate II.—Photomicrograph of sample 2, − 35 + 115 fraction. Reflected light. Linear magnification × 8.

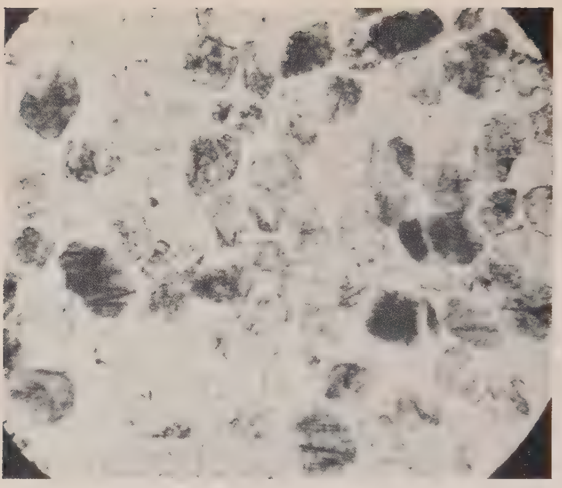

Plate III.—Photomicrograph of sample 2, — 35 + 115 fraction, in immersion liquid of refractive index 1·56. Transmitted light. Linear magnification × 18.

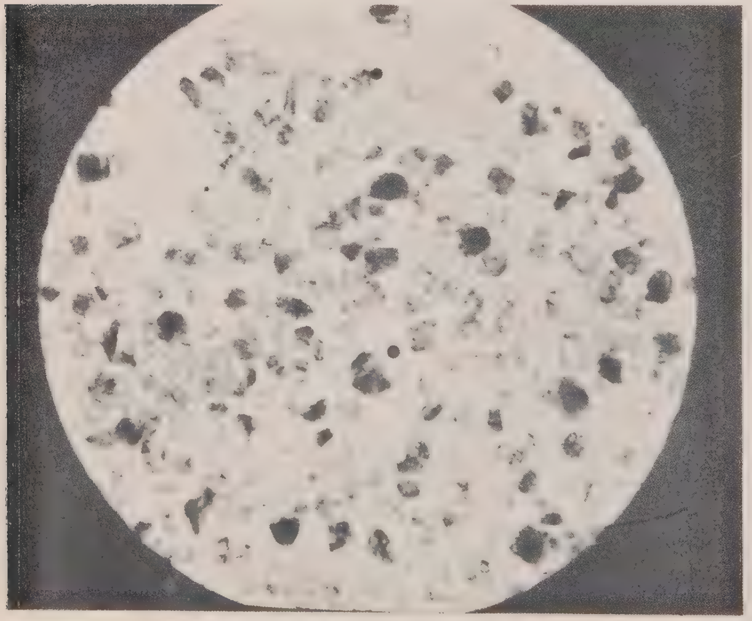

Plate IV.—Photomicrograph of glass sand from Fontainebleau (France), one of the best glass sands known, in immersion liquid of refractive index 1·56. Transmitted light. Linear magnification × 18.

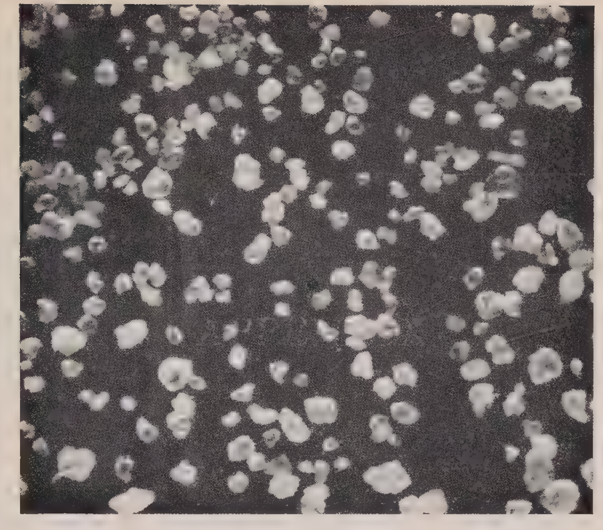

Plate V.—Photomicrograph of sand sample 36, Zeekoehoek 95, − 35 + 115 fraction. Reflected light. Linear magnification × 8.

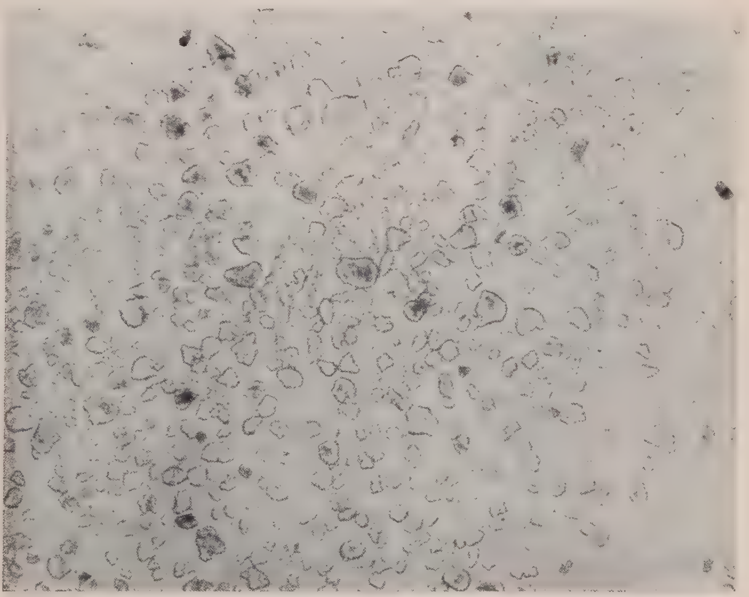

Plate VI.—Photomicrograph of sample 36 (acid-treated), − 35 + 115 fraction, in immersion liquid of refractive index 1·51. (Quartz = 1·55). Transmitted light. Linear magnification × 8.

APPENDIX

Pretoria–Hercules–Schoemansville–Magaliesburg railway line

Height in feet above sea-level	Miles from Pretoria	Stations, *sidings*, and ***halts***
4,593	—	Pretoria
4,547	1	*Pretoria West*
4,330	4	Hercules
4,355	5	*Helen Street*
4,392	6	*Wes-Aapies*
4,390	6	*Riekert*
4,400	7	*Camp Street*
4,398	8	*Sandpits*
4,428	8	*Gomsand*
4,440	10	*Mooka*
4,430	11	*Fortsig*
4,296	14	*Pioneer*
4,208	15	*Swartspruit*
4,171	17	*Iswin*
4,150	18	*Longmeadow*
4,135	20	*Saartjies Nek*
4,120	21	*Sanadu*
4,010	22	*Schoemansville*
4,056	25	*Nefdt*
4,145	29	*Damsig*
4,215	33	Skeerpoort
4,210	35	*Lynkloof*
4,295	37	*Die Moot*
4,295	40	*Martiena*
4,460	43	Hekpoort
4,448	45	*Foothills*
4,560	49	*Doornspruit*
4,705	51	*Elberta*
4,750	52	*Seekoeihoek*
4,682	56	Magaliesburg

MECHANICAL AND CHEMICAL ANALYSES

Farm	Sample number	Mechanical composition (Tyler sieves)								Treatment of sample	Chemical composition		
		+ 28 (above 0·6 mm.)	− 28 + 35 (0·4 to 0·6 mm.)	−35 + 48 (0·3 to 0·4 mm.)	− 48 + 65 (0·2 to 0·3 mm.)	− 65 + 100 (0·15 to 0·2 mm.)	−100+115 (0·125 to 0·15 mm.)	(− 115 below 0·125 mm.)	Total − 35 + 115		SiO$_2$	Fe$_2$O$_3$	Other constituents
		per cent.	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.		per cent.	per cent.	per cent.
Uitzicht 586 (Iswin siding area)	1 2 3	4 2 6	12 8 16	23 19 25	27 26 24	17 18 13	3 3 2	14 24 14	70 66 64	Untreated (*a*) Untreated (*b*) − 35 + 115 − 35 + 115 + acid Unsieved + acid Untreated Washed (Wilfley) Untreated Unsieved + acid	98·9 98·8 99·2 99·2 99·3 98·9 99·2	0·098 0·100 0·053 0·028 0·062 0·097* 0·045* 0·120 0·070	FiO$_2$ = 0·12 Al$_2$O$_3$ = 0·36
Uitzicht 586 (Swar.spruit siding area)	4 5	5	12	21	24	16	3	19	64	Untreated − 36 + 100 B.S.I. − 36 + 100 B.S.I. + acid		0·099* 0·072* 0·052*	
Zandfontein 93..........	8 9 10 11	2 7 11 10	13 25 20 21	31 33 29 26	26 22 22 20	16 7 10 10	3 1 1 1	9 6 8 12	76 63 62 57	Untreated Bulk (*a*) Sample (*b*) − 35 + 115		0·039* 0·061* 0·069* 0·052	
Hartebeestpoort 308......	13 14 15	6 9 14	19 21 25	27 23 22	23 17 14	13 11 8	2 2 2	11 18 16	65 53 46	− 35 + 115		0·062	
Pienaarspoort 176........	16 17 18 19 20 21	2 3 1 2 2 4	13 13 7 12 9 16	30 28 23 30 19 25	28 29 28 27 24 22	17 18 24 16 22 15	3 3 4 3 4 3	8 7 14 10 20 15	78 78 79 76 69 65	− 35 + 115 + acid Untreated (*a*) Untreated (*b*) − 35 + 115 − 35 + 115 + acid Unsieved + acid Untreated Washed (Wilfley) − 36 + 100 B.S.I. washed − 36 + 100 B.S.I. + acid	 98·9 97·9 99·1 98·8 98·8 99·0 99·1	0·137 0·110 0·113 0·064 0·057 0·060 0·105* 0·058* 0·054* 0·045*	
Witfontein 53...........	22 23	6 4	17 18	25 27	21 21	14 12	3 2	14 16	63 62	Untreated − 36 + 100 B.S.I. − 36 + 100 B.S.I. washed − 36 + 100 B.S.I. + acid − 36 B.S.I. washed − 100 B.S.I. washed		0·210* 0·157* 0·088* 0·052* 0·136* 0·380*	
Wonderboom 311........	25 26	5 7	17 16	25 23	22 21	15 15	3 3	12 15	65 62	− 35 + 115		0·060	
Rietfontein 28...........	27 28	4 4	11 11	20 20	29 27	19 19	3 3	14 16	71 69	Untreated Untreated (*b*) − 35 + 115 − 35 + 115 (*b*) − 35 + 115 + acid	 99·3	0·120 0·105† 0·064 0·063† 0·041	TiO$_2$ = 0·16† Al$_2$O$_3$ = 0·875† TiO$_2$ = nil† Al$_2$O$_3$ = 0·137 †
De Rust 18..............	31 32	7 7	17 16	20 20	22 22	14 14	2 2	17 19	58 58	Untreated − 35 + 115 − 35 + 115 + acid	98·3 98·7 98·7	0·129 0·093 0·073	
Remhoogte 40...........	33	8	16	19	22	14	2	18	57	− 35 + 115	97·4	0·139	
Bultfontein 120..........	34	3	8	16	27	23	4	19	70	− 35 + 115 − 35 + 115 + acid	97·9 98·4	0·153 0·123	
Zeekoehoek 95...........	35 36 37	5 5 5	16 17 16	20 21 21	24 24 24	19 16 18	3 3 3	14 14 12	66 64 66	Untreated − 35 + 115 − 35 + 115 + acid − 35 + 115 + acid	98·3 98·2 99·2 98·4	0·138 0·074 0·046 0·100	
Strydfontein 606.........	39 40	7 8	17 15	21 18	21 20	15 18	3 3	16 17	60 59	− 35 + 115 − 35 + 115	98·0	0·146 0·111	
Hartbeesthoek 524.......	41	5	12	17	20	18	3	25	58	− 35 + 115		0·139	
Philippi, Cape Flats (treated at quarry)	52	1	13	28	28	20	3	7	80	Untreated − 35 + 115 − 35 + 115 + acid		0·035† 0·012† 0·008†	TiO$_2$ = trace† Al$_2$O$_3$ = 0·285†
Philippi, Cape Flats (stated to have been taken from wall of pit)	53	24	17	18	19	16	2	5	54	Untreated − 35 + 115 − 35 + 115 + acid	99·6	0·024† 0·019† 0·015†	TiO$_2$ = trace† Al$_2$O$_3$ = 0·176† TiO$_2$ = trace† Al$_2$O$_3$ = 0·181†

* Analyst: I. Donen. † Analyst: C. J. Liebenberg. All other analyses by C. F. J. v.d. Walt.

VERALGEMEENDE GEOLOGIESE KAART VAN DIE MOOT-GEBIED, PRETORIA, WAT DIE VINDPLEKKE VAN DIE SANDMONSTERS AANTOON.

GENERALISED GEOLOGICAL MAP OF THE MOOT VALLEY AREA, PRETORIA, SHOWING POSITIONS OF SAND SAMPLES.